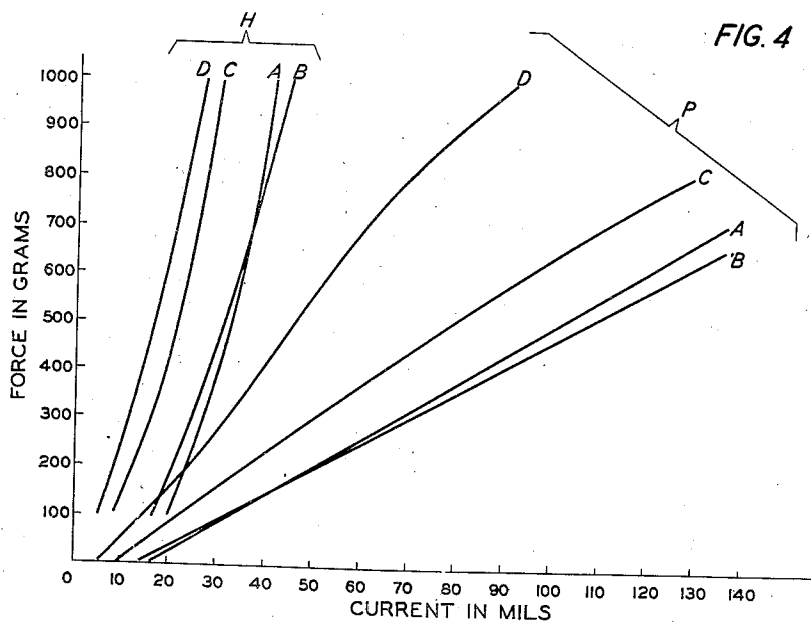
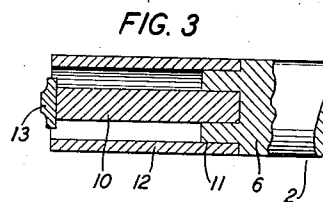
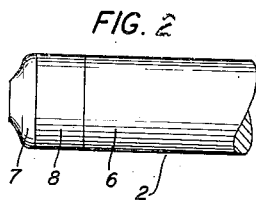
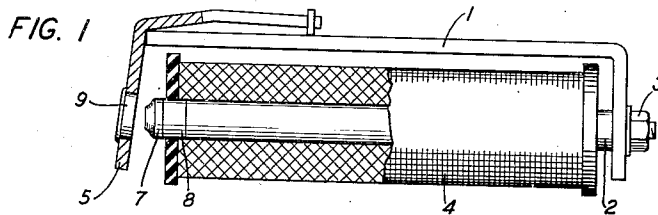


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ELECTROMAGNETIC DEVICE

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ELECTROMAGNETIC DEVICE

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1 Claim. (Cl. 175—339)

This invention relates to electromagnetic devices and has for its object the provision of means of a simple character whereby the armature of an electromagnetic device may be held in its operated position without requiring the continued energization of the energizing coil of such device.

In electrical systems it is often necessary to operate an electromagnet or relay and to hold it so operated for a considerable period. For example, certain of the relays and magnets used in establishing connections in telephone systems of the dial switching type become energized when the calling subscriber initiates a call and are held in their operated condition until the conversation is terminated. This period may therefore be of several minutes duration. Obviously, so long as the conventional magnet or relay remains operated, current is required to maintain its operating coil energized. In some instances the strength of the current may be reduced from an operating value to a holding value but still some current is required to maintain the device operated and this current drain while relatively slight for a single device becomes quite a factor of operating cost in a large telephone system where a great number of such devices must be held simultaneously operated. It has been estimated that in an office, for example, of the crossbar type having ten thousand subscribers' lines, used at three-quarters of its capacity, the current drain would constitute about thirty per cent of the total load. Furthermore due to the heat generated in the winding of an electromagnetic device, if it is held operated for any great length of time, such a device has to be designed with respect to heat dissipation capability, thus adding to its initial cost.

In accordance with the present invention, the aforementioned object is attained by the insertion in the core of an electromagnetic device consisting of a small section of permanent magnet material which normally has insufficient magnetization to operate or to even hold the armature of the device operated, but which due to the passage of the magnetizing current through the coil normally used to operate the armature, becomes magnetized with sufficient strength to hold the armature in its operated position after the flow of current through the operating coil is entirely discontinued whereby the armature will remain in its attracted position until forcibly removed or until the magnet is demagnetized below its holding strength by means of the passage of reversed current

through the operating coil or by opening an auxiliary gap in the magnetic circuit.

If the return magnetic circuit of an electromagnetic device has low reluctance, the short section of permanent magnet material may be inserted between the main body of the core and the pole-piece face of the core and of such a diameter that the total residual flux concentrated in the pole face will provide the required holding force. The length of the section of permanent magnet material is determined chiefly by the reluctance of the remainder of the magnetic circuit when the armature is in its operated position.

If the return magnetic circuit has considerable reluctance, the short section of permanent magnet material may be of smaller diameter than the core and inserted between the end of the core and the pole face thereof. The permanent magnet section is then surrounded by a shell of permalloy of the same diameter as the core, the forward edge of which serves as an auxiliary core pole face. Sufficient magnetizing current is employed to saturate the shell around the permanent magnet so that the magnet will also become saturated and thereby strongly magnetized when the armature pulls up. When the magnetizing current is removed, the armature is held by the flux through the permanent magnet, the armature and the shell. The armature is released by the transmission of an impulse of current through the coil in the reverse direction which demagnetizes the permanent magnet.

For a clearer understanding of the invention, reference may be had to the following detailed description taken in connection with the accompanying drawing in which:

Fig. 1 is a top view of a magnet, partly in cross section, showing the application of the invention thereto.

Fig. 2 is an enlarged view of the forward end of the core of the magnet shown in Fig. 1;

Fig. 3 is an enlarged view, partly in cross section, of the forward end of a magnet or relay core constructed in accordance with a modified form of the invention; and,

Fig. 4 shows two sets of curves, one set illustrating the initial pull-up force vs. current and the other set the maximum holding force in the operated position of the armature after the operating current has been removed vs. the operating current, for magnets provided with permanent magnet sections of the type disclosed in Figs. 1 and 2 and of four different lengths.

Referring first to Figs. 1 and 2, the invention

has been disclosed as applied to the hold magnet of a crossbar switch of the type disclosed, for example, in Patent 2,021,329 granted November 19, 1935, to J. N. Reynolds. This magnet comprises an L-shaped return pole-piece 1, to the short arm of which the core 2 is secured by the nut 3 threaded upon the rear threaded portion of the core. The core 2 extends forwardly parallel to the long arm of the return pole-piece and has an operating coil 4 supported thereon. An armature 5 is pivoted on the forward end of the long arm of the return pole-piece for attraction toward the end of the core 2.

In accordance with the invention, the core 2 comprises a rear section 6 of the usual core material, a pole face section 7 and an interposed section 8 of permanent magnet material. Preferably the three sections are of the same diameter and are butt-welded together and then heat treated. The permanent magnet section 8 may be made of "vicalloy," a magnetic alloy having a composition of approximately 38 per cent iron, 52 per cent cobalt and 10 per cent vanadium or other material of high coercivity. To obtain a large B²A factor or pull the pole-face section 7 and the insert 9 in the armature 5 may be made of "permendur," a magnetic alloy having a composition of approximately 49 per cent iron, 49 per cent cobalt and 2 per cent vanadium, which material will permit of a high flux density without unduly increasing the reluctance of the magnetic circuit. In the operation of the magnet, the application of operating current to the coil 4 sets up a flow of flux in the magnetic circuit which is sufficient to attract the armature and to magnetize the section 8. When thereafter the operating current is removed, the magnet section 8 being now magnetized concentrates a sufficient flux density in the pole face section 7 to hold the armature 5 in its operated position. To release the armature 5 to its normal position, it is necessary to forcibly pull it away from the pole face section 7 of the core or to demagnetize the permanent magnet section 8 by applying current momentarily to the coil 4 of a polarity reverse to the operating current. After its demagnetization, the magnet section 8 possesses insufficient magnetic strength to cause the attraction of the armature 5 or to hold it attracted should it be manually moved to its operated position. This structure is particularly advantageous in relays or magnets which have relatively low reluctance magnetic circuits.

Should the magnetic device have a magnetic circuit of considerable reluctance, the modified structure shown in Fig. 3 is preferable. In this structure, the forward end of the rear section 6 of the core is provided with an axial hole in which a short section 10 of permanent magnet material, such as "vicalloy," is seated and with a circumferential recess 11 in which is seated a shell 12, preferably of molybdenum permalloy, which saturates at a moderate flux density. To further improve the operation a pole face section 13 of "permendur" may be welded to the forward or free end of the magnet section 10. When the operating coil is energized, the armature is attracted to the pole face of the shell 12, and when the shell becomes saturated a large part of the flux is directed through the central magnet section 10 thereby causing it to become magnetized. When the energizing current is removed the permanent magnet section 10 holds the armature operated through the local magnetic circuit consisting of magnet 10, the armature and

the shell 12. To release the armature, current of the opposite polarity is applied to the operating coil thereby demagnetizing the magnet section 10.

The effectiveness of hold magnet cores of the type shown in Figs. 1 and 2 has been proven experimentally and the results of such experiments are illustrated graphically by the curves of Fig. 4. For the purpose of the experiments a magnet coil of 22,000 turns was employed and four different cores were used: core A having a permanent magnet section 8 one and one-quarter inches in length; core B having a section one inch in length; core C having a section three-quarters inch in length and core D having a section one-quarter inch in length. The group P of curves indicates the initial pull-up force vs. current, the force being measured in grams in line with the center of the core pole face and with an armature air-gap of 0.1 inch and the operating current being measured in milliamperes. From this group of curves it appears that the shorter the section 8 of magnet material employed the greater is the magnetic pull secured with the same strength of operating current. Thus, for example, with a current of 50 milliamperes, core A one and one-quarter inches long gave a pull-up force of 220 grams, whereas core D one-quarter inch long gave a pull-up force of 570 grams. The decreased pull-up force with the longer magnet is due to the added reluctance in the magnetic circuit which is equivalent to an air-gap roughly ten per cent of the length of the permanent magnet material used in these tests.

The group of curves H indicates the maximum holding force vs. the operating current, the holding force being the force, measured in grams in line with the center of the core pole face with the armature operated and after the operating current is removed, necessary to pull the armature away from the core, and the operating current being the current measured in milliamperes used to attract the armature with no load applied thereto. It will be noted that for the core D with one-quarter inch magnet section, the pull required to break the armature away from the core varied from 100 grams, after a five milliamperere energizing current was removed, to 1,000 grams after a 27 milliamperere energizing current was removed. It is also to be noted that the curves for the cores A, B and C having longer lengths of permanent magnet sections, show that greater initial energizing currents were required to secure the same holding force, as for example the core A requiring an energizing current of 44 milliamperes to secure the holding force of 1,000 grams as compared with 27 milliamperes for the core D.

From these experiments it appears that the length of the permanent magnet material is determined chiefly by the reluctance of the remainder of the magnetic circuit when the armature is in its operated position. If the section is too short the coercivity will not be sufficient to maintain a large holding flux after the magnetizing current is removed and on the other hand if it is too long, it requires an unduly large magnetizing force to operate the armature and to magnetize the permanent magnet and then requires an excessive reverse current to release it. In the case of the shorter magnet sections, a reverse current equal to about ten per cent of the operating value of the current was found sufficient to release the armature.

Further experiments have indicated that the section of permanent magnet material may be reduced to one-sixteenth inch in length and still provide a strong holding force. A core thus equipped and magnetized by a winding of 15,000 turns energized by an operating current of 20 milliamperes gave a hold value of over 1200 grams after the removal of the operating current. It is thus quite significant that a simple magnet structure having such a short piece of permanent magnet material inserted in series in the core can hold an armature operated against such a force without operating current other than the brief impulse of current required for the initial operation.

The use of a thin section of magnet material has the further advantage that the demagnetizing current required to release the armature becomes correspondingly small. In a practical design a thin magnet charged, by operating current, to a value that can sustain a load of 900 grams, will be released by the application of reverse current equal to five per cent or less of the normal operate current.

The invention while illustrated as applicable to magnets is equally applicable to relays of many types well-known in the art, that is, magnets with armature actuated contacts. Such relays when so modified are not restricted to operation by current of a particular polarity but may be operated equally well by current of either polarity and released by the application of current of the opposite polarity and of lesser strength. Permanence of magnetization of the permanent magnet material is required only during the relatively short operating times. Thus, a material which might gradually lose its magnetization in longer intervals such as a week or a year would be entirely satisfactory if it holds its magnetization in a magnetic circuit of low reluctance during relay operate times.

Due to the polar and marginal properties of the magnetic structure in accordance with the present invention, it would be possible to obtain

selective operation of chosen groups of relays thus equipped, or the operation of other auxiliary equipment without interference with the normal functions. This could be accomplished by the use of currents or trains of impulses of the same polarity as the normal operating current which, of course, would not disturb the holding of the relay equipped with the permanent magnet core section.

It is to be understood that while the release of a magnetically held armature has been described as effected by a reversal of current, through the operating coil of the electromagnetic device the release could be effected by forcibly pulling the armature away or by opening the magnetic circuit at a suitable point therein.

What is claimed is:

In an electromagnetic structure, a core comprising a rear section having an axial hole and a circumferential recess on its forward end, a bar of permanent magnet material such as "vicalloy," a magnetic alloy of vanadium, iron and cobalt, or other material of high coercivity, seated in said hole and having a pole-face section of magnetic material permitting a high flux density therein such as "permendur," a magnetic alloy of cobalt and iron, secured to its outer end and a thin shell of magnetic material such as permalloy which permits saturation at a moderate flux density seated in said recess and surrounding said bar, said shell being separated from said bar and said pole-face by an air-gap, an armature attractable to said pole-face section and to the forward polar edge of said shell, said bar magnet being normally insufficiently magnetized to either cause or maintain the attraction of said armature to said core, and a coil on said core energizable to attract said armature and to magnetize said bar magnet sufficiently to hold said armature attracted after the deenergization of said coil and until said bar magnet is reversely magnetized.

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